

Original Article

A Retrospective Study of Sexual Dimorphism Based On Frontal Sinus Assessment

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INTRODUCTION

Person recognition via radiographs has always been a fertile ground for deciphering skeletal developmental patterns and yielding promising results. Radiographs are a simple, cost-effective, and practical approach that has been used in the past. Radiographic comparison of osteological features has long been used to validate the identity of decomposed, burned, or otherwise disfigured human remains. The posterior–anterior frontal skull radiographs, among other radiographs, have proved to be a potentially valid method for individual recognition.^[1] Due to their unusual form and peculiar appearance, many structures such as the sella turcica, mastoid air cells, paranasal sinuses, and particularly the frontal sinuses have been used for this function.^[1-3] Zukerkandl *et al.* (1895)^[4] were the first to notice the uniqueness of the frontal sinus. Later many experts have used the frontal sinus for forensic purposes and elaborate its uniqueness, individuality, as well as human identification in postmortem situations.^[1,5,6]

The air-filled cavities in the frontal bone expand with age. Around the age of 5 or 6 years, these cavities are radiologically visible, and by the age of 20 years, they have fully developed.^[3,4] Previous research has shown that the frontal sinuses vary from person to person, even in monozygotic and dizygotic twins, implying that they have human morphological differences.^[3,5,7,8,9-12] While gender, race, and disease are known to influence the development of the frontal sinus, it is often said to be influenced by numerous environmental factors.^[13,14]

ABSTRACT

Purpose: Person recognition via radiographs has always been a fertile ground for deciphering skeletal developmental patterns and yielding promising results. This study was performed to evaluate the uniqueness and reliability of the frontal sinus by comparing various parameters on the digital posteroanterior skull radiographs for sex identification.

Materials and Methods: The present study comprised digital posteroanterior radiographs and frontal sinus was analyzed for morphometric parameters by Adobe® Photoshop® CS3 extended in 30 subjects (15 males and 15 females) aged between 18 and 40 years. The comparison of values was done and accuracy of sex determination was assessed.

Results: Statistically significant difference was found. The mean values for length, width, and area of the left frontal sinus were found to be higher in males as compared to females.

Conclusion: The frontal sinus provides average accuracy in sex determination as it is unique to every individual and ultimately this can aid in human identification. Posteroanterior skull radiographs have proven to be a potential valid tool for individual identification.

KEYWORDS: Digital posterior–anterior radiograph, frontal sinus, nasal septum

Few studies have investigated the use of the frontal sinus as a personal identifying aid, according to evidence-based sources. The current study was performed in this context to assess the differences in frontal sinus seen on posterior–anterior skull radiographs and their potential for use in personal recognition.

MATERIALS AND METHODS

A retrospective study of 30 individual radiographs was conducted, with 15 males and 15 females varying in age from 20 to 40 years. Since sinus formation is completed about the age of 20, and since atrophic shifts and gradual pneumatization cause a reduction throughout dimension in the older age group, a narrow age range was desired. Healthy people were included in the study. Patients who had undergone orthodontic treatment, orthognathic surgery, trauma, or had inherited facial asymmetries were excluded from the study. A panorex OPG Machine was used to take a digital posteroanterior skull. The frontal sinus was then examined on a subset of radiographs.

METHODOLOGY

In all digital radiographs, a line was drawn immediately between all orbital cavities, the nasofrontal suture was standardized, and then measurements were taken for right and left height (RT HT), right and left width (RT WD), and right

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and left field (RT AR), both from the portion of the frontal sinus projected above the baseline [Figures 1 and 2]. The frontal sinus septum was used to separate the left and right sides of the sinus, allowing for one diameter to be measured on either side. The interval between two predicted lines that delineate the maximum lateral limits of the right and left sinuses was determined at the widest points of the frontal sinuses. At the highest superior point of the frontal sinuses, a line parallel to the nasofrontal line was drawn, and the difference between the two lines was determined.

RESULTS

The average left length was 1.11 cm in females and 1.39 cm in males among the 30 patients, while the right length was 0.91 cm in females and 1.28 cm in males. The difference in length between the right and left sides was statistically significant ($P = 0.00$). Females had an average left width of 2.10 cm, while males had an average left width of 2.50 cm. Females had an average right width of 1.84 cm, while males had an average right width of 2.21 cm. The difference between males and females in width was found to be statistically significant ($P = 0.00$). Females have a lower total left frontal sinus region (2.21 cm²) than males (3.04 cm²). Males had a greater right frontal sinus region (2.840 cm²) than females (1.77 cm²), and the discrepancy was statistically significant ($P = 0.05$) [Figures 3 and 4].

DISCUSSION

The use of radiological investigations has increased and become more common over the last decade due to the development of newer techniques that aid in forensic identification. However, no useful demographic data for a standardized recognition protocol is available. As a result, archiving previously acquired radiographs will solve these challenges. Since the skull is normally less vulnerable to injury from inhumation, radiographs of the frontal sinuses are successfully used for personal identification. As a result, the skull is used to determine sex with a precision of 77%–92%^[1-5] through the estimation of morphological or osteometric

measurements.^[2,3,6,7] The morphology of the frontal sinus aids in positive identification in cases of unknown human remains, particularly when they are highly immolated or decomposed, due to its highly variable and relatively stable structure.^[2,3,5,9] Furthermore, the frontal sinus is unaffected by the interval between autopsy and death.^[4,10,12] Radiographs are often used in forensic anthropological examinations, particularly where skeletal remnants are not adequately recorded. The anatomy of the frontal sinus is diverse due to its dimensions, form, and location, which can be seen in all radiographs of frontal sinuses. The use of radiographs to assess and delineate the anatomical structure of paranasal sinuses was first recorded by Scheier in 1896.^[2]

Males and females were equally represented in our sample, with 15 males and 15 females (50 percent each), similar to the study by Mathur *et al.*,^[13] Mary *et al.* (2009),^[14] Camargo *et al.*,^[15] and Hamed *et al.*^[16] In contrast to these, 190 males and 220 females (unequal numbers) were included in a study conducted by Cakur B *et al.* (2011).^[17] In our sample, the average right and left lengths in males and females were 1.28 and 0.91 cm, and 1.39 and 1.11 cm, respectively, and the average left and right width in females and males were 2.10 and 1.84 cm and 2.50 and 2.21 cm, respectively. According to the study by Hanson and Owsley,^[18] Pondé *et al.*,^[19] Szilvássy,^[20] Ertugrul *et al.*,^[21] and Farias and Gonzalez^[22] showed that the males have longer and wider dimensions of frontal sinus than in females, similar results were seen in our study. This disparity may be attributed to morphological variations between ethnic groups and different radiographic methods used to evaluate the morphology of the frontal sinuses. Owing to the flat arrangement of sinuses or lateral divergence of the nasal septum to the left or right, the horizontal diameter of the frontal sinus indicates relatively little variation. As a result, combining the use of the frontal sinus with the contrast of pre- and postmortem frontal skull radiographs can be useful for identification.^[2,3,5]

The average left frontal sinus area in our sample was 3.40 cm² in males and 2.21 cm² in females and the average area of the right frontal sinus region in males was 2.84 cm² and in females was 1.77 cm². Rubira-Bullen *et al.*^[23] found that the

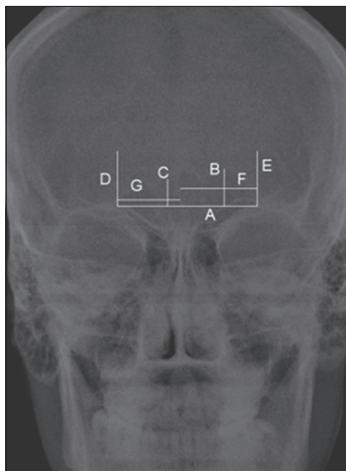


Figure 1: Posteroanterior radiograph showing demarcation of borders of the frontal sinus and identification of the measurements collected with the aid of a reference baseline

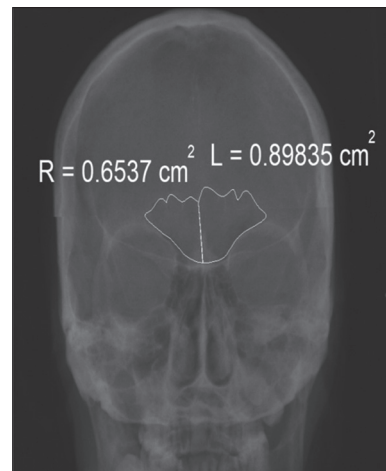


Figure 2: Frontal sinus area accessed with Autocad software

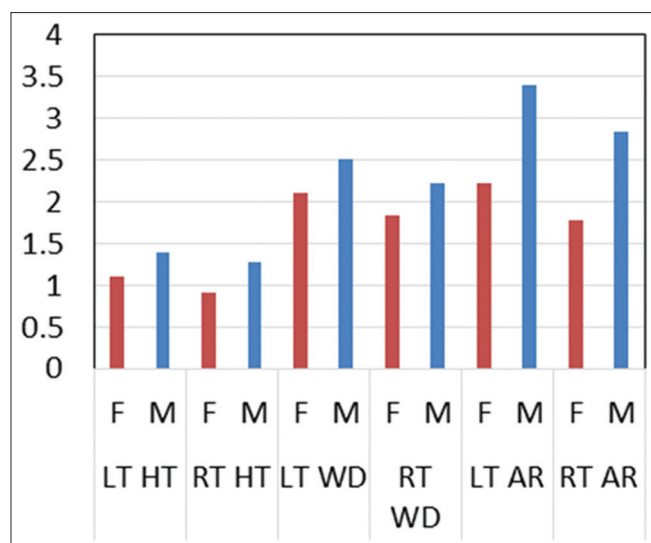


Figure 3: Gender-wise mean value variation in right and left parameters of frontal sinus

area of the frontal sinus was important in relation to gender. Males' frontal sinuses were observed to be larger than females' frontal sinuses, according to Buckland-Wright,^[24] Pandeshwar *et al.*, 2017,^[12] Pondé *et al.*,^[19] and Harris *et al.*, 1987.^[25] The study by Ertugrul *et al.*^[21] and Camargo *et al.*^[15] suggested that the genetic, dietary, physiological, and physical causes play a role in the morphological variations in the cranium between men and women. Such factors can explain why men's frontal sinuses are on average larger than women's frontal sinuses.

The left height, width, and area were considered to be the most appropriate for gender determination in our study, and the results were consistent with those of Camargo *et al.*^[15] and Uthman *et al.*^[26] The findings of other research by Gulisno, Pacini, and Orlandini (1978), Ertugrul *et al.*,^[21] and Rubira-Bullen *et al.*^[23] all pointed that the left side is greater than the right.

LIMITATIONS OF THE CURRENT STUDY

First, only individuals age 20 years and above were considered due to sinus formation which is completed about the age of 20, and since atrophic shifts and gradual pneumatization cause a reduction throughout dimension in the older age group, a narrow age range was desired. Second, the use of a small sample size which would be less representative of the Indian population; hence, a larger sample size should be considered. Third, it should include inter or intraobserver variations.

CONCLUSION

There was a scarcity of research on sexual dimorphism in the Indian population, especially in relation to morphological evaluation of the frontal sinus and forensic applications of all morphological parameters; hence, the current study attempted to identify sex based on frontal sinus evaluation. Thus, a posterior-anterior skull radiograph is a simple, fast method for a preliminary screening in the event of a mass disaster. However, to confirm this, we recommend more research using newer parameters for determining gender, age, personal

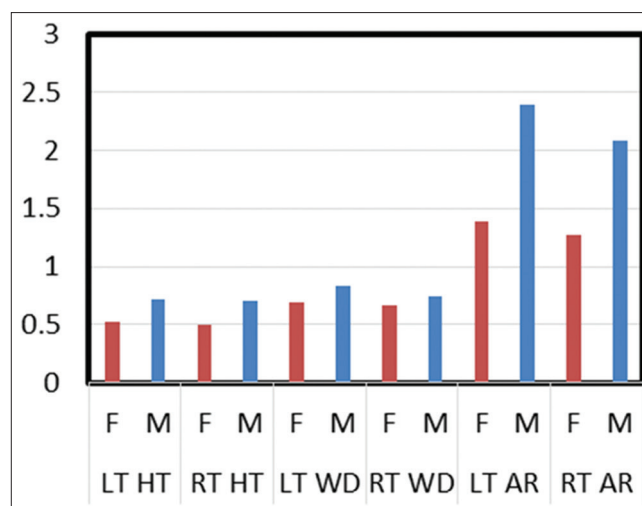


Figure 4: Gender-wise standard deviation in right and left parameters of frontal sinus

identification, and the consideration of various ethnic groups, as well as the use of a larger sample size.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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